Use of a multiple choice questionnaire to assess UK prescribing channels' knowledge of helminthology and best practice surrounding anthelmintic use in livestock and horses

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ABSTRACT

Grazing livestock and equines are at risk of infection from a variety of helminths, for which the primary method of control has long been the use of anthelmintics. Anthelmintic resistance is now widespread in a number of helminth species across the globe so it is imperative that best practice control principles be adopted to delay the further spread of resistance. It is the responsibility of all who prescribe anthelmintics (in the UK, this being veterinarians, suitably qualified persons (SQPs) and pharmacists) to provide adequate information on best practice approaches to parasite control at the point of purchase. Poor uptake of best practice guidelines at farm level has been documented; this could be due to a lack of, or inappropriate, advice at the point of anthelmintics purchase. Therefore, the aim here was to evaluate levels of basic knowledge of helminthology, best practice guidelines and dispensing legislation among veterinarians and SQPs in the UK, through a Multiple Choice Question (MCQ) test, that was distributed online via targeted emails and social media sites. For each respondent, the percentage correct was determined (for the MCQ test overall and for subsections) and the results analysed initially using parametric and non-parametric statistics to compare differences between prescribing channels. The results showed that channels generally performed well; veterinarians achieved a mean total percentage correct of 79.7% (range 34.0-100%) and SQPs, a mean total percentage correct of 75.8% (range 38.5-100%) ($p=0.051$). The analysis indicated that veterinarians performed better in terms of knowledge of basic helminthology ($p=0.001$), whilst the SQP group performed better on legislation type questions ($p=0.032$). There was no significant difference in knowledge levels of best practice between the two channels. Multivariable linear regression analysis showed that veterinarians and those answering equine questions only performed significantly better than those answering all questions. Based on information gaps identified by analysis of individual questions, a number of areas for improvement in knowledge transfer to both channels are suggested to improve the quality of advice at the point of anthelmintics purchase.

1. Introduction

All grazing livestock and equines are at risk of infection from a variety of helminths, and these parasites can have a substantial negative impact on animal productivity, health and welfare (Love et al., 1999; Charlier et al., 2014). For the last half century, the main method of controlling helminth infections has been the application of anthelmintics. Until recently, for nematodes, three broad spectrum anthelmintic classes were primarily used for this purpose: benzimidazoles, imidazothiazoles/tetrahydropyrimadines and macrocyclic lactones (Prichard, 1990). There are also a variety of flukicide products licenced for the treatment and control of trematode infections (Fairweather and Boray, 1999). Recently, two new anthelmintic compounds were licenced and marketed for use in the control of nematode species in sheep in several countries. These compounds are monepantel (Zolvix®, Elanco Animal Health), which is an amino-acetonitrile derivative compound (Kaminsky et al., 2008), and derquantel (a spiroindole), which is combined with the avermectin, abamectin (Startect®, Zoetis) (Little et al., 2011). Resistance (including multi-class resistance) to the traditional classes of anthelmintic is widespread in nematodes of cattle, small ruminants and equids (Bartley, 2011; Sutherland and Leathwick, 2011; Kaplan and Vidyashankar, 2012; Papadopoulos et al., 2012; Matthews, 2014) and there have been reports of resistance to the commonly used, most broad spectrum flukicide, triclabendazole (Fairweather, 2011; Flanagan et al., 2011). Moreover, the first reports of resistance to monepantel are already published (Scott et al., 2013; Mederos et al., 2014). With regard to pigs, resistance has been reported to benzimidazoles and imidazothiazoles/ tetrahydropyrimadines in the EU (Gerwert et al., 2002); however, there is a lack of published data on anthelmintic resistance status in worms this host species.

In the UK, the two new classes of anthelmintic can be dispensed only by veterinarians or by pharmacists on veterinary prescription (Prescription Only Medicine – Veterinarian, POM-V). All the other classes are categorised under a Prescription Only Medicine – Veterinary, Pharmacist, Suitably Qualified Person (POM-VPS) label and can be dispensed by Registered

Qualified Persons, the types of which are Veterinarians, Pharmacists and Suitably Qualified Persons (SQPs). A SQP must possess a qualification awarded by the Animal Medicines Training Regulatory Authority (AMTRA; http;//www.amtra.org.uk/), a body appointed under the Veterinary Medicines Regulations by the UK Secretary of State. There are a number of SQP categories in relation to the animals for which they can prescribe; there are various combinations, each of which is assigned a lettered code to describe an individual's permit in the prescribing and supply of medicines (Table 1). Prescribers can be located at a variety of premises such as veterinary surgeries, feed merchants, pharmacies and online. It is the responsibility of prescribers to provide information on current best practice approaches to parasite management at the point of purchase. In the UK, these are described in industry guidelines such as the Sustainable Control Of Parasites in Sheep (SCOPS, http://www.scops.org.uk/ (Abbott et al., 2012)) and Control Of Worms Sustainably (COWS, http://www.cattleparasites.org.uk/ (EBLEX, 2010)). No such guidelines exist for horses in the UK, but similar principles apply as laid out in guidelines of the American Association of Equine Practitioners (http://www.aaep.org/info/parasite-control-guidelines). For pigs, guidelines are described by the Responsible Use of Medicines in Animals Alliance (http://www.ruma.org.uk/pigs/anthelmintics-pigs/). A number of farmer and horse owner surveys indicate that there has been a relatively poor uptake of the guidelines (Morgan and Coles, 2010; McMahon et al., 2013). Risk factors highlighted as important in preserving anthelmintic efficacy are not widely implemented, particular examples being the use of effective quarantine or in the calculation of accurate dose rates (Barton et al., 2006; Relf et al., 2012). It is imperative that best practice control principles be adopted by farmers and horse owners to delay further dissemination of anthelmintic resistance and to preserve efficacy of the currently effective products.

In 2013, the British Veterinary Association (BVA) lobbied the UK Veterinary Medicines Directorate (VMD) to make changes to the Veterinary Medicines Regulations with regard to

reclassifying all anthelmintics as POM-V. The BVA's argument was underpinned by the assumption that SQP knowledge of parasitology is inferior to that obtained in the course of a full (5 to 6-year) undergraduate veterinary degree (Anon, 2013b). In EU countries such as Denmark and the Netherlands, legislation requires the involvement of a veterinarian and the establishment of a parasitological diagnosis prior to dispensing anthelmintics and prohibits treatment on a prophylactic basis (Nielsen et al., 2006). In a rebuttal from their Secretary General (Anon, 2013a), AMTRA argued that the BVA claims were unsubstantiated and cited facts such as the persistence of anthelmintic resistance in countries employing 'vet-only' prescribing systems, as well as on-going concerns surrounding prescribing practices and resistance with regard to veterinarian-only prescription antimicrobials. With these views in mind, there is little quantitative or qualitative published evidence on which to base the assumptions that either veterinarians or SQPs are better placed to prescribe anthelmintics. For this reason, the aim here was to evaluate levels of knowledge in these channels through execution of a multiple choice question (MCQ) test covering basic helminthology knowledge, prescribing legislation and best practice principles surrounding helminth control.

2. Materials and Methods

2.1. Ethical Statement

Approval for the survey was granted by the UK Department for Environment Food & Rural Affairs (DEFRA) Survey Control Unit. With regards to respondent confidentiality, all information was stored on a secure server at the Moredun Research Institute (MRI). Data on this server is backed up daily at an external site.

2.2. Study population

For selection of veterinarians, details of large animal (i.e. livestock and equine) practices in the UK were obtained from the Royal College of Veterinary Surgeons (RCVS) database. The database was cross-checked to group branch practices together, and to omit practices that were not first-opinion practices, such as referral services, or services related to fertility or embryo transfer. The details were also cross-checked with practice websites to establish that the veterinarians contacted currently covered ruminant, pig and/or equine species. This resulted in a list of 755 UK-based veterinarian/practice emails. A further 384 veterinarian/practice emails were obtained from a British Equine Veterinary Association (BEVA) list to give a total of 1,139 veterinary surgeons or practices on the mailing list. Note that was not possible to determine the exact number of veterinarians working on each species at each practice. An email inviting the veterinarians to take part in the survey was distributed directly, detailing an introduction to the study and a link to the MCQ test in SurveyMonkey (www.surveymonkey.com, see below). The same link was shared on the pages of the following groups on Twitter (https://twitter.com/): the BVA, BEVA, British Cattle Veterinary Association (BCVA), Pig Veterinary Society (PVS), and Sheep Veterinary Society (SVS), as well as the large animal veterinary practice group, XLVets (http://www.xlvets.co.uk/). The MCQ test link was also shared via websites or forum pages of the SVS, PVS, BEVA and the BVA. The SQP sample was achieved directly via Mr Stephen Dawson, Secretary General of AMTRA. A total of 2,847 SQPs covering advice provision for the equine, ruminant and pig industries (i.e. E, EA, G, J, K, L and R-SQP license holders (Table 1)) were emailed directly from AMTRA Head Office with the same text and link sent to the veterinarians. The same link was shared on Twitter at https://twitter.com/SQPWebinars. Email invitations to take part in the survey were also distributed to SQP members of the Animal Health Distributors' Association (AHDA, http://www.ahda.co.uk). This is an organisation comprising UK animal health product distributors and represents 90% of the POM-VPS and Non-Food Animal – Vet, Pharmacist, SQP animal medicines' market.

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153 *2.3. Study design*

154 The survey comprised several demographic questions to ascertain the profession, age,
155 gender and location of each respondent. These were followed by knowledge-based questions
156 (in MCQ format), all of which were intended to ascertain a respondent's ability to advise on
157 helminth control in line with current UK legislation and best practice guidelines. This was
158 achieved through the assessment of knowledge of basic helminthology (for example, in the
159 identification of common species names of helminths and their host predilection site),
160 epidemiology (for example, the time of year at which acute or chronic helminth-associated
161 disease may be observed), best practice guidelines (for example, advice for quarantine
162 treatments), current UK legislation (for example, meat withdrawal periods of specific
163 products in particular hosts) and the use of parasite diagnostics (for example, the application
164 of faecal worm egg count analysis). The MCQ test (including the correct answers) is
165 available as Supplementary Material (Appendix 1). To maintain consistency between
166 professional groups, a variety of information sources were used to design the test, including
167 veterinary parasitology textbooks, SQP training manuals, and information available from
168 online Continued Professional Development (CPD) guides. Informed consent was sought
169 before answering any questions. There was no time limit imposed upon respondents, who
170 were permitted to return to the form indefinitely (this decision being based on feedback
171 provided in the pilot phase where those working as SQPs stated that this would allow them to
172 be interrupted by customers while completing the survey during working hours). However,
173 respondents were not permitted to return to a page once it had been completed and exited. In
174 the case of all except the demographic questions, respondents were provided with four
175 possible responses to each question, for which only one answer was correct. The respondents
176 were directed to questions based on their particular qualification (in the case of SQPs) or on

their client base (in the case of veterinarians). Details of which questions sets were answered by SQPs and veterinarians is presented in Table 1. Of the 78 questions, nine covered general legislation, 38 related to farm animal helminthology (i.e. sheep, cattle and pig associated questions) and 29 related to equine helminthology. In both farm animal and equine sections, the final three questions were "scenario" type questions, based on a real world situation in which a client would be seeking specific advice at the point of dispensing. The survey questions were transferred to and disseminated using the online, cloud-based survey creation software, SurveyMonkey. The test was piloted on a small number of veterinarians and SQPs before being distributed to the participants. The survey was open for 3.5 months (May-September), with monthly reminder emails sent directly to each channel through the distribution lists. Reminders were also posted on Twitter to the relevant group's sites as detailed above. A flow chart depicting the progression plan for participants of the online survey can be found in Supplementary Materials (Appendix 2). On completion, respondents were redirected to the MRI parasitology homepage (www.moredun.org.uk), last accessed on 8 September 2015.

2.4. Data Analysis

All responses were recorded using SurveyMonkey software and exported to Microsoft Excel for manipulation (Microsoft Excel for Windows, 2010). Median completion times were calculated for the study sample overall as well as for each channel. As all responses required a single answer, all were coded binomially as 1=correct or 0=incorrect, and the percentages of questions correct overall and in question subsets analysed. Initially, basic descriptive statistics were used. The performance of each channel ('Vet'; 'SQP') and subsequent qualification (SQP) or client base (veterinarian) – 'farm only'; 'equine only'; 'farm and equine' - were compared in a number of areas including: percentage of questions correct

overall, percentage of questions correct for each question type (i.e. helminthology, best practice and legislation type questions) and by host (i.e. questions covering helminthology in relation to cattle (n=12), sheep (n=8), pigs (n=3) and equines (n=16)) and also the average time taken per question, as well as for the entire test. Comparisons were made using two sample t-tests, where data were normally distributed, and a non-parametric alternative, where data were not normally distributed (Mann-Whitney test). Next, univariable and multivariable linear regression analyses were carried out including the demographic variables and channel and host questions to investigate any effect that these may have on the overall percentage of questions answered correctly. A backward elimination was performed whereby variables with p-values >0.05 were removed. All statistical analyses were carried out using Minitab statistical software (Minitab 17; Minitab Inc.). Finally, stage analysis was carried out on the performance on individual questions with the aim of establishing not only differences in knowledge between channels, but to identify gaps in knowledge, within the entire study sample or between channels. This was done by identifying questions where less than 60% of respondents had answered correctly.

3. Results

3.1. Study sample and demographics

A total of 560 respondents were recorded in SurveyMonkey; 342 veterinarians and 218 SQPs. Of the respondents that clicked on the link, 227 veterinarians (Table 2) and 57 SQPs (Table 3) completed the test. A total of 244 respondents ceased participation after the demographic questions and a further 32 respondents terminated at the scenario type questions. Further analysis is based on the 284 respondents who completed the test. In the veterinarian sample, the distribution closely matched that of the general veterinary population (taken from

226 those registered with the RCVS) in terms of the proportion of male and female veterinarians
227 registered and the proportionate age range. This was also the case for location distribution,
228 with the majority of veterinarian respondents residing in the southern regions of England. In
229 the SQP sample, the distribution also reflected that of the general SQP population (when
230 compared to those registered with AMTRA), with more female respondents than male and
231 most respondents aged in the range 30-59 years. However, in the SQP sample, slightly more
232 respondents resided in northern England, the Midlands and Scotland, as opposed to southern
233 England, where there is a higher distribution of the general SQP population (as registered
234 with AMTRA).

235

236 *3.2. Completion time*

237 The median completion time overall was 19 min, and ranged from 6 min to 23 h and 45
238 min (Table 4). The median completion time for veterinarians was 18 min (range: 6 min - 22 h
239 and 45 min). The median completion time for SQPs was 31 min (range: 8 min - 23 h and 45
240 min). Further analysis revealed that for veterinarians, 92.5% (n=210) completed the test in
241 less than one hour, 5.7% (n=13) in one to four hours, 0.4% (n=1) in five to twelve hours and
242 1.3% (n=3) in thirteen hours or more. For SQPs, 68.4% (n=39) completed the test in less than
243 one hour, 28.1%% (n=16) in one to four hours, 1.8% (n=1) in five to twelve hours and 1.8%
244 (n=1) in thirteen hours or more. Veterinarian completion times were significantly faster than
245 that of the SQPs ($p<0.01$). When separated into qualification/client base groups (i.e. 'farm
246 only', 'equine only', 'farm and equine'), completion times were significantly different
247 between veterinarian and SQP respondents in all groups, with the exception of the farm only
248 respondents.

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3.3. Percentage of questions correct

Analysis of the percentage of questions correct overall (Table 5), showed that there was no significant difference between the two channels, although veterinarians (mean 79.7%, range 34.0-100%) achieved a higher per cent correct than the SQPs (mean 75.8%, range 38.5-100%) ($p=0.051$). When questions were broken down into respective type, there was a significant difference in performance on helminthology questions ($p=0.001$), with veterinarians achieving a higher percentage correct than SQPs. There was also a significant difference in performance on legislation questions ($p=0.032$), with SQP respondents achieving a higher percentage correct than veterinarians. There was no significant difference in the percentage correct attained by each channel in best practice type questions.

In the farm-only question subset, there was no significant difference in percentage of questions correct in both best practice and legislation question types between the veterinarian and SQP respondents. In this subset, there was a significant difference in the percentage correct in helminthology type questions ($p=0.02$), with veterinarians achieving a higher per cent correct than SQPs. In the equine only questions, there was no difference in the percentage correct between the channels in either helminthology or best practice questions; however, there was a significant difference in the percentage correct on legislation type questions ($p=0.01$), with SQPs achieving a higher percentage correct compared to the veterinarian group. There was no significant difference in the percentage of questions correct between the veterinarians and SQPs that answered all questions (i.e. the farm and equine grouping). When the questions were broken down into host species groups (i.e. cattle only questions, sheep only questions, equine only questions, pig only questions and questions relating to more than one host species), analysis of the percentage correct identified that there were no significant differences in performance of the veterinarian and SQP groups (Table 6).

3.4. Multivariable linear regression analysis

The final regression model (Table 7) showed that 'channel' and 'question set' were the only significant variables. The SQP respondents achieved lower scores than the veterinarian respondents and the equine only group performed better than those answering all questions (i.e. farm and equine grouping). Neither age nor gender had an effect on the MCQ test outcomes.

3.5. Gaps in knowledge identified through analysis of performance per individual question

The questions for which <60% of the sample achieved correct answers across and within channels can be found in Supplementary Materials (Appendix 3). Of the entire test, there were 11 questions that met this criterion for both channels. There was one additional question for which <60% of respondents were correct in the veterinary channel and a further nine questions with respect to the SQP channel. Of the 11 questions for which <60% of the entire sample gave the correct answer, five were cattle-specific, three were sheep-specific and one each for equine and pig related questions. The majority of these questions covered basic helminthology (i.e. questions relating to helminth species names, predilection sites, times of the year relevant to specific clinical observations and intermediate hosts). There were also a number of legislation questions for which low scores were obtained; these related to the licencing of anthelmintics (with regard to pigs, specifically), and to reporting resistance to the licensing authorities. Of concern, all questions regarding meat withdrawal periods achieved low results. Additionally, with regards to best practice, two scenario questions achieved low results in both channels overall. In the case of the veterinary sample, respondents had lower scores than SQPs on a single equine-related question, relating to the prepatent period of *Parascaris equorum*. The SQPs had lower scores on several questions, particularly those

299 covering Fasciolosis, the predilection site of a helminth in pigs, the migration route of
300 *Strongylus vulgaris*, an equine best practice scenario question and a question relating to the
301 layman's term for *Paramphistomum cervi*.

302

303 **4. Discussion**

304 This study aimed to compare UK-based veterinarian and SQP knowledge with respect to
305 the prescribing and supply of anthelmintic products. The results indicate that, in general, both
306 the veterinarian and SQP groups performed well. The veterinarian group performed better
307 than SQPs on helminthology questions in particular, while the SQP group performed better
308 than veterinarians with regard to legislation knowledge. Equine only respondents performed
309 particularly well in the MCQ test. Stage analysis identified a number of gaps in knowledge
310 relating to the responsible prescribing of anthelmintics in the case of the overall group of
311 respondents, as well as in individual channels. The multivariable linear regression analysis
312 indicated that the veterinary respondents performed better overall than the SQPs after
313 allowing for question set. In reality the difference was small and appeared to be primarily in
314 those questions covering general helminthology knowledge. This observation can perhaps be
315 attributed to differences in the characteristics of veterinarians, particularly, educational ability
316 (Hudson et al., 2009) and a higher level of training as undergraduates. Veterinarians spend
317 time studying helminthology in specific courses within their degree, as well as knowledge
318 garnered in relation to pathogen types, pharmacology, therapeutics and control strategies.
319 Likewise, when the MCQ test results were separated into topics (parasitology, best practice
320 and legislation), the results indicated that veterinarians had a better knowledge of general
321 helminthology than SQPs, while the latter scored a higher percentage correct on legislation
322 questions; in particular, the equine only SQP respondents performed significantly better than
323 the veterinarian group. The results suggested that there was no significant difference in basic

knowledge of best practice principles of control between the groups. The generally high results on the best practice questions are encouraging as they indicate that veterinarians and SQPs are informed on the main principles surrounding the responsible prescribing of anthelmintics.

The response rate was poor, with relatively low numbers of veterinarians and SQPs proceeding to click the link to the MCQ test. In the case of the SQPs, response rates were particularly disappointing. Only 218 out of the 2,847 emailed AMTRA-registered SQPs covering advice provision for equine, ruminant and pig industries clicked on the MCQ test link. In 2015, according to the AMTRA register database, there were 171 farm only SQPs, 1,248 equine only SQPs and 2,242 mixed qualification SQPs – this is equal to 4.7% farm only, 34.1% equine only and 61.2% mixed qualification. These numbers are reflective of the respondents who participated here, as the sample consisted of 7 (12.3%) farm only, 18 (31.6%) equine only and 32 (56.1%) mixed qualification SQPs. In the case of the veterinarian respondents, it is not possible to compare the study sample to the entire population of UK registered practicing veterinarians as the RCVS does not hold data regarding the specific practice (i.e. patient species) type of individual veterinarians; however, the general demographic data matched the available RCVS data well. Response rates for web or internet surveys are known to be generally low; it is suggested that this could be due to a lack of information available regarding the most effective ways to motivate individuals to respond in comparison to longer established survey methods such as telephone or mail surveys.

The completion rate (i.e. respondents who began the survey and finished the test) was poor in the case of the SQPs, with only 26.1% of respondents completing the test, compared to the veterinarian completion rate which was 66.4%. Most respondents that did not complete the test, did not progress beyond demographic questions. The remainder that did not complete the test terminated when they reached the scenario sections. The length of the test may have

discouraged respondents from completing it. It has been suggested that web surveys should adhere to a number of design rules to limit non-response (Dillman et al., 1998). One is to not require that individuals provide an answer before being allowed to proceed to the next question, as this could result in early termination. However, the test here was not a 'traditional survey' and this rule would have hindered the ability to calculate an overall score for individuals had they been able to skip questions which they were unsure of. Furthermore, allowing question skipping could result in questions being missed accidentally, adding the issue of ascertaining whether questions had been intentionally skipped or accidently missed. Self-selection bias is a limitation of online survey research (Wright, 2005) and the findings here must take into account the poor response and completion rate. Individuals who participated and completed the test may have been more likely to do so due to a number of biases, including the likelihood that those who completed it were individuals with greater confidence in their ability and/or knowledge of the subject matter. There is also the possibility that individuals who completed the test were more comfortable with its digital format/question design than those who chose not to. Due to the higher non-completion rates of SQP respondents, these biases could be magnified, leading to a greater possibility of bias amongst this sample. For example, those SQPs who completed the test could be a concentrated sample of the population with high confidence in their knowledge, with more time to dedicate their full attention to the survey or with easier access to the internet. As a result, it would be useful to implement measures in future to increase response and completion rates to try reduce bias; for example, the offering of incentives (this was considered by the authors here; however, was not permitted by the funding body), implementing pre-notifications and/or working closer with stakeholders in encouraging respondents by awarding CPD points to those that complete the test (here, this was offered to AMTRA as an option but was not taken up).

Veterinarians completed the test significantly faster than SQPs, though there was only a 13-minute difference between the respondent groups in the median completion time. A number of reasons could explain the difference, similar to those considered with regard to differences in test performance. For example, the quicker completion times of veterinarians could be attributed to the fact that those who participated were generally more experienced in MCQ test format or had more time to concentrate on the test without distraction due to the nature of their working environment.

The analysis of individual questions highlighted gaps in knowledge that could benefit from having a greater emphasis placed on them during training and CPD programmes. Of the ten questions that did not meet the 60% correct threshold, half covered cattle parasitology. Two questions were within the 'farm animal scenario' section, that offered respondents the option to select, 'More information is required before a recommendation can be given', which garnered most answers. The issue created as a result of offering this option could be considered similar to that posed by providing respondents with a 'no-choice option', whereby respondents, faced with a difficult decision, select this as an easy option, resulting in an absence of the necessary effort needed to come to an appropriate choice resolution (Dhar and Simonson, 2003). However, the basic nature of the remaining three questions on cattle helminths support a recommendation that training needs to be more effectively tailored to the inclusion of helminth species infecting these animals. This might reflect a relative lack of concern regarding anthelmintic resistance within the cattle sector, where, historically, the problem has not been regarded as widespread as in the sheep and equine sectors. It is notable though that anthelmintic resistance in cattle nematodes is being increasingly reported world-wide (Geurden et al., 2015). Another area of concern was in the level of answers correct on questions relating to meat withdrawal period. Low scores here were achieved by veterinarians and SQPs. This is of concern because food safety is an important issue for policy makers and the general public (Cooper et al., 2011). In addition to those questions that

achieved low results across both channels, there were a number of questions that achieved low percentage correct totals in each channel. In the SQP sample, 9 questions fell below the 60% threshold and the results suggest that SQPs could benefit from adjustments in the syllabus or CPD training regarding information provided on *F. hepatica* epidemiology. This is an important pathogen that has a wide host range (including humans) and has substantial clinical and economic impacts in grazing ruminants (Toet et al., 2014). Other questions achieving low results covered basic parasitology (Latin names or predilection sites), perhaps suggesting that the issues resulting in poor SQP performance on these questions are methodology related (for example, a misunderstanding of the language used in the question or answers provided). Alternatively, this could be the result of differences in learning methods experienced by veterinarians and SQPs; including the shorter time that SQPs spend learning this information compared to veterinarians who are exposed to parasitological-related information at various stages through their full time 5-6 year undergraduate degree. It is important to note that, with the exception of the scenario questions, the questions in this MCQ test demonstrate knowledge/recall that is likely to be at the lower end of the Bloom's Taxonomy cognitive dimension learning pyramid (Krathwohl, 2002). As a result, the outcomes of this study need to be augmented by further work on how this knowledge is applied in 'real life' situations. To do this, the authors are currently exploring (using further questionnaires), the channels' practices, methods and opinions on best practice knowledge dissemination at the point of prescribing by surveying both prescribers and end-users (i.e. farmers and horse owners). Moreover, this MCQ test will be made freely available to those that train UK veterinary undergraduates, SQPs and veterinary pharmacists to be used as a formative revision exercise in large animal helminthology, best practice and anthelmintics prescribing legislation.

It is notable that the section of the MCQ test covering equines achieved consistently high results in both channels. It is possible that the greater scores achieved here is due to better

426 knowledge in this specialist host grouping, or methodological reasons, such as the equine
427 question set consisting of easier questions than those of the farm animal question set. The
428 human-horse relationship is one considered to be emotional due to the potential for long term
429 companionship (Schuurman, 2014). It is possible that this type of connection between owner
430 and horse somehow shapes interactions between prescribers and equine clients/customers –
431 resulting in prescribers engaging better in the learning process. Furthermore, horse owners'
432 potential higher awareness of anthelmintic resistance, and therefore expectations for treatment
433 options, could dictate the degree of knowledge required by the prescriber. The increased
434 opportunity to tailor treatment plans to individual animals could also mean that prescribers
435 dealing with equine clients/customers have better knowledge and understanding of
436 information relevant to anthelmintics. It would be advantageous to carry out further
437 investigation to identify factors responsible for this evident better knowledge among equine
438 prescribers so that their principles can be extrapolated and employed in knowledge transfer to
439 other prescribing groups.

440

441 **5. Conclusion**

442 The results show that, despite some apparent gaps in knowledge, both veterinarian and
443 SQP respondents in this study had a sound knowledge of the basic information necessary in
444 the prescription and distribution of anthelmintics. The apparent high level of knowledge in
445 most respondents of best practice principles of control is encouraging with regards to their
446 ability to advise end-users on measures for mitigating the spread of resistance and to preserve
447 efficacy of currently effective anthelmintics. This needs to be balanced, however, against the
448 poor response and completion rates and the unknown quality of knowledge in those who did
449 not perform or complete the test. The identification here of gaps in knowledge in both
450 channels provides the opportunity for improvement in knowledge transfer to further develop

the quality of advice at the point of anthelmintics purchase. Furthermore, the evidence gleaned can be put to use in informing policy in terms of those best qualified to prescribe anthelmintics in the UK and abroad.

Conflict of Interests

There were no conflicts of interest in the implementation of this project.

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Table 1. Breakdown of criteria that determined the specific question set that respondents were directed to in the MCQ test, based on their qualification (in the case of SQPs) or on their type of clinical practice (in the case of veterinarians)

Profession/Qualification	Permissible medicines	MCQ test question set [c]
SQP qualification code[a]		
R-SQP	All VPS medicines	Mixed
G-SQP	VPS: Farm animals and equines only	Mixed
K-SQP	VPS: Farm and companion animals only	Farm only
E-SQP	VPS: Equine and companion animals only	Equine only
L-SQP	VPS: Farm animals only	Farm only
J-SQP	VPS: Equines only	Equine only
JA-SQP	VPS: Equine and avians only	Equine only
EA-SQP	VPS: Companion animals, equines & avians only	Equine only
Veterinarian practice type[b]		
Farm/production animals only	NA	Farm only
Equines only	NA	Equine only
Farm/production animals & equines	NA	Mixed

[a] SQP qualification codes are based on the specific AMTRA modules which the individual has passed

[b] Veterinarian practice types are based on which species individuals work with (i.e. farm/production animals only, equines only or both farm/production animals and equines)

[c] Question sets were determined based on animal species that the individual is permitted/likely to prescribe and/or supply to

NA - Veterinarians are permitted to prescribe medicines to all species

568

569 **Table 2.** Survey sample demographics for the veterinarian group

570

Demographic category		UK Practising Veterinarian Respondents				Veterinary Sample %	Overall Population %[b]
		Practice Category					
		Farm only	Equine only	Farm and Equine	Total (n)		
		103 (45.4%)	68 (30%)	56 (24.7%)	227[a]		
Respondent age (years)	18-29	31	15	13	59	26.0	23.1
	30-39	36	31	22	89	39.2	33.9
	40-49	14	13	7	34	15.0	20.9
	50-59	13	6	13	32	14.1	14.9
	60+	8	3	1	12	5.3	7.2
	NA	1	0	0	1	0.4	0.0
Gender	Male	53	23	25	101	44.5	40.7
	Female	50	45	31	126	55.5	59.3
	NA	-	-	-	-	-	0.0
Location	Scotland	7	6	16	29	12.8	10.2
	N. England	14	18	17	49	21.6	19.1
	N. Ireland	1	4	2	7	3.1	3.8
	Wales	2	3	8	13	5.7	5.2
	Midlands	10	15	3	28	12.3	14.2
	S.E. England	22	16	2	40	17.6	34.1
	S.W. England	11	39	6	56	24.7	13.4
	NA	1	2	2	5	2.2	0.0

571 [a] Total respondents that completed the test: i.e. 227/342 (66.4% completion rate)

572 [b] Based on a comprehensive list of UK practising veterinarians - provided by the RCVS on 03/11/2015

573 NA – respondents did not provide demographic data

574 **Table 3.** Survey sample demographics for the SQP group

575

Demographic category		Project sample				SQP Sample %	Overall Population %[b]
		SQP Category					
		Farm only	Equine only	Farm and Equine	Total		
Total n (%)		7 (12.3%)	18 (31.6%)	32 (56.1%)	57[a]		
Respondents age (years)	18-29	2	2	6	10	17.5	20.6
	30-39	3	3	5	11	19.3	27.3
	40-49	1	7	4	12	21.1	22.7
	50-59	1	2	11	14	24.6	20.2
	60+	-	4	5	9	15.8	9.0
	NA	-	-	1	1	1.8	0.3
Gender	Male	1	1	16	18	31.6	42.7
	Female	6	17	15	38	66.7	57.2
	NA	-	-	1	1	1.8	0.2
Location	Scotland	3	1	7	11	19.3	9.6
	N. England	6	4	4	14	24.6	18.3
	N. Ireland	-	-	1	1	1.8	6.4
	Wales	-	1	1	2	3.5	13.0
	Midlands	4	1	8	13	22.8	16.3
	S.E. England	4	-	7	11	19.3	19.6
	S.W. England	1	-	4	5	8.8	16.7
	NA	-	-	-	-	0.0	0.0

576

577 [a] Total respondents that completed the test: i.e. 57/218 (26.1% completion rate)

578 [b] Based on a comprehensive list of AMTRA registered SQPs provided by AMTRA on 27/10/2015

579 NA – respondent did not provide demographic data

580

581

582 **Table 4.** Median completion times, ranges for completion times and Mann Whitney results

583 for the MCQ test overall, by channel and by qualification/client base

584

Channel		Completion time (hh:mm:ss)	Range (hh:mm:ss)	Mann Whitney p-value
Overall		00:19:00	00:06:00 – 23:45:00	
Vet		00:18:00	00:06:00 – 22:46:00	<0.001
SQP		00:31:00	00:08:00 – 23:45:00	
Qualification/Client base				Mann Whitney p-value
Farm only	Vet	00:18:00	00:06:00 – 22:46:00	0.3
	SQP	00:21:00	00:12:00 – 01:11:00	
Equine only	Vet	00:13:30	00:06:00 – 04:41:00	0.03
	SQP	00:18:00	00:08:00 – 01:08:00	
Farm and Equine	Vet	00:25:50	00:10:00 – 22:46:00	0.0007
	SQP	00:47:50	00:17:00 – 23:45:00	

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586

587 **Table 5**. Mean per cent of MCQ test correct by channel (veterinarian, SQP) and question set

588 (farm only, equine only, both farm and equine)

589

Question subsection	Percentage of MCQ test questions correct (95 % CI)		t Test p –value
	Vet (n = 227)	SQP (n = 57)	
Overall	79.7 (78.4-80.9)	75.8 (72.1-79.5)	0.051
Parasitology	80.9 (79.3-82.4)	72.3 (67.4-77.2)	0.001
Best practice	81.7 (80.0-83.4)	78.0 (74.4-81.6)	0.06
Legislation	77.6 (75.9-79.4)	82.1 (78.4-85.9)	0.03
	Farm only participants:		
	Vet (n = 103)	SQP (n = 7)	
Parasitology	77.9 (75.7-80.0)	63.8 (53.1-74.5)	0.02
Best practice	83.7 (80.8-86.6)	73.0 (57.5-88.6)	0.1
Legislation	77.4 (74.4-80.4)	78.0 (68.5-87.6)	0.8
	Equine only participants:		
	Vet (n = 68)	SQP (n = 18)	
Parasitology	89.7 (87.5-91.9)	84.4 (76.7-92.1)	0.1
Best practice	82.0 (79.4-84.7)	82.1 (76.1-88.1)	0.9
Legislation	78.8 (76-81.6)	87.0 (81.7-92.4)	0.008
	Farm and Equine participants:		
	Vet (n= 56)	SQP (n= 32)	
Parasitology	75.6 (72.5-78.6)	69.8 (62.6-76.9)	0.6
Best practice	77.6 (74.4-80.7)	76.7 (71.9-81.6)	0.7
Legislation	76.6 (73.2-79.9)	80.3 (74.6-86.0)	0.2

590

591

592 **Table 6**. Percentage correct across questions covering helminths specific to certain animal

593 species.

Host species (number of questions per species group)	Mean percentage correct (95% CI) Farm participants[a]: Vet (n=159)	SQP (n=39)	t Test p –value
Cattle (12)	72.7 (70.0-75.4)	62.8 (57.4-68.2)	0.2
Sheep (8)	80.4 (78.1-82.7)	64.7 (59.5-69.9)	0.1
Pigs (3)	78.0 (76.4-79.6)	59.8 (51.1-63.5)	0.1
Mixed (4)	86.6 (84.1-89.2)	76.9 (71.8-82.0)	0.4
	Median percentage correct (range) Equine participants[b]: Vet (n=124)	SQP (n=50)	Mann Whitney p -value[c]
Equine (16)	89.9 (40.0-100.0)	78.0 (56.5-100.0)	0.2

594 [a]All participants answering farm/production animal questions

595 [b]All participants answering equine questions

596 [c]Analyses were carried out using non-parametric methods due to non-normal distribution of the equine

597 veterinarian data

598

599

600 **Table 7**. Multiple regression model for percentage correct for each respondent on the MCQ
601 test (n =284) including channel (veterinarian and SQP) and question set (All, farm-only and
602 equine-only) variables

	n	Coefficient	Standard error of coefficient	p-value
Intercept		0.76	0.01	<0.001
Channel				
Veterinarians	227	Reference category		
SQPs	57	-0.03	0.02	0.04
Question set				
All	88	Reference category		
Farm	110	0.03	0.02	0.07
Equine	86	0.09	0.02	<0.001

603